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Task Title:

MEMS Reliability

Responsible Center:	Responsibility:
JPL, Proposing Center	Mr. Russell Lawton, JPL
GSFC, Contributing Center	Mr. Harry Shaw, GSFC
JSC, Contributing Center	Dr. Alice Lee, JSC

Program Group:

MEMS Reliability Assurance

Benefit:

This work, by its uniqueness, will help infuse MEMS into mainstream applications, and specifically, space applications where many studies showed the benefits and added-value of MEMS, but still have big lacks and misses on the behavior of these components in the space environment (radiation, etc.) and on their reliability issues.

Beneficiaries:

All four NASA strategic enterprises: Aeronautics, Human Exploration and Development of Space Enterprise, Mission to Planet Earth, and Space Science.

Objective:

This project aims to address the reliability of Micro Electro Mechanical Structures and Systems Things to monitor include optical/SEM inspection for breakage, sticking, and delamination of films. Other more quantitative monitoring would include resonance measurments using the Polytech before/after testing and the associated behavior shift under radiation.

Alignment with Program Objectives:

This task actively supports the program objective of providing NASA projects with technology selection, application, and assurance guidelines for MEMS Reliability.

Deliverables:

- Characterization results from MEMS devices supplied by partners.
- Predictive models for the fabrication and operation of MEMS devices.
- Novel, device-specific characterization and modeling techniques.
- Conference publications and presentations of characterization and modeling results.

Technical Approach:

JPL, GSFC and JSC will work together to achieve the following goals:

Task 1 : Procure and Characterize MEMS devices

Partnerships have been established with the Microdevices Laboratory within JPL and with outside organizations such as Cronos (MCNC foundry) and Aerospace Corporation. These partners will supply the MEMS devices being developed for NASA applications. These devices will be examined at each stage of fabrication in order to build in the reliability into the fabrication process. The partners will be provided with the results of the characterization and modeling.

Task 2 : MEMSCAP Model Refinement

Our partner MEMSCAP has a product (which is unique on the market today), which enables the user to develop an Analog Behavioral Model (written in HDL-A) for the device under test, either directly from experimental results or from Finite Elemental Modeling (FEM)/ Behavioral Elemental Modeling (BEM). The characterization results from Task 1 will provide information on failure mechanisms and measurements of the required electrical, mechanical, and thermal parameters for model validation. The characterization data will be sent to MEMSCAP and a model refinement operation will be done internally at MEMSCAP. The modified models will be sent back to the Failure Analysis Laboratory and will be supplied to the device providers on request.

Task 3: Development of Novel Characterization and Modeling Tools

MEMS devices are unique and very different from standard ICs in that a “cookie cutter” approach cannot be adopted to characterize and model all devices. In a majority of the instances, it has been found that new characterization and modeling techniques need to be

developed to fully understand the fabrication and operation of each device. 3-D visualization tools developed by the Failure Analysis Laboratory in collaboration with Polytec PI have successfully demonstrated the value of these novel imaging/modeling techniques to the device developers and fabricators.

Task 4: Improve Manufacturing Yield and Reliability

The ultimate goal of the MEMS Reliability Assurance task is to help develop robust, high-yield manufacturing processes that provide reliable devices for Space Qualification. To this end, it is important that the reliability be built into every step of the manufacturing process via characterization, statistical analysis and modeling. We will develop a thorough understanding of potential failure mechanisms, both in the fabrication and operation of devices, on a device by device basis. Failure analysis can be conducted both at a macroscopic (device level) as well as a microscopic, atomic level. Unique instruments are currently available at JPL such as, an Atomic Force Microscope (AFM), a Chemical Residual Gas Analyzer (RGA), and an Infrared (IR) camera, all of which have been integrated into an Environmental Scanning Electron Microscope (ESEM), in order to measure device performance in-situ, and at high resolution. This knowledge of potential failure mechanisms is essential for developing accurate risk assessments.

Furthermore, once working devices are achieved, long term reliability of MEMS devices will be actively investigated. Long duration space missions that use MEMS devices for critical functions such as inertial guidance will require reliable data on parameters such as performance drift.

Task 5: Dissemination of Information

Several groups/laboratories around the country have undertaken the reliability testing of MEMS devices for various applications. Publications in the literature and presentations at conferences will be the primary media for the dissemination of information.

Partners/Collaborators:

Although the primary alliance will be between JPL, GSFC, JSC, Cronos, Aerospace Corporation, Polytec PI and MEMSCAP, Naval Surface Warfare Center